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Assessing Judgment Proficiency in Army Personnel

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Personnel Decisions Research Institutes, Inc.

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U.S. Army Research Institute

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14. ABSTRACT *(Maximum 200 words*:

Because of the unpredictable nature of the Army's current conflicts, operational requirements demand that Soldiers and leaders become proficient in military judgment and decision-making. This research presents an analysis of military judgment proficiency (MJP), which is judgment and decision-making in environments characterized by cultural, legal/ethical, and tactical complexity. We reviewed relevant literature in the areas of judgment, decision-making, and problem-solving to present a sound theoretical foundation for the MJP construct. We defined MJP as a complex skill and argued that in ambiguous, novel, rapidly changing situations in which there is limited time, information, and resources, Soldiers demonstrating MJP are more likely to select an effective course of action by appropriately identifying the nature of the situation, recognizing relevant situational factors, and forecasting the best overall outcome(s), given the situation. We describe also the initial stages of development of an assessment tool that will distinguish among Soldiers on MJP, and lay out future plans for test validation with Special Forces and non-Special Forces Soldiers.

15. SUBJECT TERMS: Military judgment Decision-making Problem-solving Situational Judgment Test (SJT) Complex cognitive skills Judgment proficiency

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ASSESSING JUDGMENT PROFICIENCY IN ARMY PERSONNEL

EXECUTIVE SUMMARY

Research Requirement:

The Army's success in the current conflicts hinges on its ability to maintain tactical and technical control in an operational environment that demands agility in mission analysis, planning, and execution. Because of the unpredictable nature of these conflicts, judgment and decision-making have emerged among the most important concepts included in new Army doctrine and as key findings in studies that sought to understand the skills with which leaders and Soldiers must become proficient. For example, a study in 2005 by the Institute for Defense Analysis (IDA) suggested that, in general, the Department of Defense (DoD) does well at training Soldiers to fight traditional, symmetric threats that dominated the conflicts of the 20th century. The authors found less evidence that current Army training doctrine and practices supported the skills necessary to deal with the asymmetric threats of the 21st century. While all the services have adopted the belief that judgment and decision-making are important to success, there is no consensus among or within services about how they should be operationally defined or universally applied.

There is a need for a systematic theoretical analysis of judgment proficiency as a military-specific component and determinant of agility and the cognitive processes associated with it (i.e., decision-making, choice rationale, etc.). Once established, a conceptual and theoretical foundation of judgment proficiency can provide a sound basis for gaining and advancing an understanding of and informing decisions about training this indicator of proficient agility in practice. There also is a need to develop reliable and valid measures of judgment proficiency that will apply to multiple Soldier populations and that are guided and refined by a theoretical framework and subsequent analyses.

The purpose of this research was to construct a sound theoretical basis for judgment proficiency and the cognitive processes involved in its application. A second purpose was to develop a theory-based measure of the judgment proficiency of Special Forces (SF) and non-SF Army Soldiers using a situation judgment test (SJT) and multiple response type approach.

Procedure:

The literature review was based on the idea that while Soldiers are limited by their capacity to search for and process information, they are nevertheless cognitively adaptive to the task environment. This theme was central to how MJP was conceived in this research, and was discussed in relation to several models of judgment and decision-making, including rational models, the Heuristics and Biases (HB) program initiated by Kahneman and Tversky, Hammond's Cognitive Continuum Theory (CCT), the Adaptive Toolbox (AT) approach proposed by Gigerenzer and colleagues, and Klein and colleagues exploration of Naturalistic Decision-Making (NDM).

The MJP measure was developed according to the SJT approach. Subject-matter experts from Special Operations Forces (SOF) provided operational stories, lessons learned, multiple response options and ratings, and continued guidance during development of the test. Follow-on research will consist of MJP test validation research with SOF and non-SOF Soldier samples.

Findings:

In our view, based on a comprehensive literature review, Soldiers make effective decisions by appropriately framing the situation and recognizing relevant situational factors, which enables them to select a course of action that is most likely to result in their desired outcome. In novel, ambiguous, rapidly changing situations in which there is limited time, information, and resources, MJP is primarily intuitive, in that it relies on domain-specific, adaptive heuristics, and well-organized knowledge to arrive at judgments quickly. If time and circumstances permit, this initial intuitive approach can be endorsed, corrected, or overridden by a more deliberate, analytical approach.

Utilization and Dissemination of Findings:

The results of this research will support SOF selection and assessment, and will serve as a sound theoretical foundation for developing Army-wide MJP training and testing. Findings were discussed with leaders at the Special Forces Assessment and Selection (SFAS) Battalion and the Command Group from the Directorate of Special Operations Proponency (DSOP).

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Introduction

The current strategic environment is characterized by geopolitical uncertainties and evolving threats. The U.S. Army's superiority in conventional operations has led adversaries to avoid direct confrontation and instead pursue indirect and irregular means to achieve their objectives (U.S. Army, 2008). The U.S. military is engaged in a number of conflicts around the world that are characterized by an enemy that is continuously adapting and engaging U.S. forces using these irregular means. Maintaining dominance over these asymmetric threats requires agile Soldiers who can maintain tactical and technical control in environments that present novel, ambiguous, and rapidly changing situations.

The dynamic and ambiguous nature of these operating environments poses a difficult challenge for Soldiers who must make decisions in situations characterized by cultural, ethical, and tactical complexity, often with limited time, information, and resources. As the Army field manual on counterinsurgency (COIN) states (U.S. Army, 2006) "The side that learns faster and adapts more rapidly…usually wins." (p. ix).

Succeeding in these types of adaptive performance situations requires a variety of knowledge, skills, abilities (KSAs), and other attributes (e.g., see Mueller-Hanson, Wisecarver, Dorsey, Ferro, & Mendini, 2009). Some of the KSAs related to agility, such as general intelligence or openness, can be assessed with standard assessment tools (see LePine, Colquitt, & Erez, 2000; Pulakos, Arad, Donovan, & Plamondon 2000; Zaccaro, 2001). Other KSAs such as problem-solving and decision-making are more difficult to assess (see Endsley & Robertson, 2000; Klein, 1997; Mueller-Hanson, White, Dorsey, & Pulakos, 2005; Shadrick, Crabb, Lussier, & Burke, 2007; White et al., 2005). In order to identify and develop Soldiers who will demonstrate a pattern of agile performance in these situations, we must define and understand these complex skills.

Our goal in this report is twofold. The first is to define and describe a skill we will call "military judgment proficiency" (MJP), which is military judgment that drives decision-making in environments characterized by cultural, legal/ethical, and tactical complexity. We consider MJP an important component of adaptive performance. The second is to describe the development of an assessment tool that will distinguish among Soldiers on this construct. Being able to assess MJP can aid in the selection and assessment of Soldiers in specialized units or teams, such as Provincial Reconstruction Teams or Special Operations units, and can serve as the basis for the development of training that targets MJP.

Based on relevant pieces of the existing judgment and decision-making literature, we conceive of MJP as a complex skill that involves: (a) accurately framing decision problems, (b) detecting and interpreting important situational factors and cues, (c) forecasting the consequences of different courses of action, and (d) choosing an effective course of action based on the preceding three factors. As such, in ambiguous, novel, rapidly changing situations in which there is limited time, information, and resources, Soldiers demonstrating MJP are more

likely to select an effective course of action by appropriately identifying the nature of the situation, recognizing relevant situational factors, and forecasting the best overall outcome(s) from the selected course of action, given the situation. In combination, these four components of MJP enable Soldiers to achieve the best possible end-state when faced with different situations. After describing the theory behind our conceptualization of MJP, we will describe the development of a measure that uses multiple formats to tap each of the components of the construct.

The first section of this report reviews relevant literature in the areas of judgment, decision-making, and problem-solving. This literature review presents the theoretical foundation for the MJP construct. In the second section of this report we will synthesize the key themes from the literature review that create the components of MJP. Finally, in the third section of the report, we describe the development of a measure of MJP using a situational judgment test format, and detail the links between the theoretical components and the measurement methodology.

Understanding Judgment and Decision-Making

Military personnel routinely face novel, dynamic situations in which to make difficult decisions under conditions of limited time and information. Research on decision-making has shown that uncertain situations create roadblocks to action and effective decision-making (Lipshitz & Strauss, 1997). Modeling and measuring how experienced Soldiers exhibit MJP and make sound decisions in these situations is an important step towards advancing the development of training targeted at improving judgment and decision-making in the field. In order to understand the critical elements of expert military decision-making, we first begin with a review and synthesis of several related literatures. We focus primarily on the study of judgment and decision-making, which sheds light on the nature of MJP for a variety of tasks and settings. We also draw upon relevant theory and empirical research from the related fields of problem-solving and critical thinking, both of which expand our understanding of expertise and proficiency in the decision-making arena. We start with a discussion of human cognitive capacity, which sets a foundation for judgment and decision-making.

Human Cognitive Capacity

Decades of research in cognitive psychology have produced two key conclusions about human cognitive capacities (Hogarth, 1987). We highlight them here because they underpin how we conceive of MJP. First, people have limited information processing capacity, especially in relation to the complexity of the tasks they routinely face. As such, humans cannot be thought of as calculators who make optimal decisions based on all available information. Rather, the human mind is more akin to a "…selective, sequential information-processing system with limited processing and memory capacity" (Hogarth, 1987, p. 10). This finding is relevant for military personnel who must take decisive action in highly ambiguous environments. When time is short and the situation requires the individual to make a decision and take action, expecting a thorough rational approach where different options are carefully weighed is neither feasible nor realistic. Therefore, if the conditions restrict individuals from taking a rational, thorough approach in

those types of situations, then it is important to understand the alternate processes they use to make a decision.

Although we indicate that humans have limited processing capacities, it would be incorrect to think of them as ineffective computers. Humans are highly adaptable and seek to understand, control, and master their environments (Hogarth, 1987). This point relates directly to the second conclusion we wish to highlight, which is that humans, despite the aforementioned limitations, are adaptive to different judgment tasks. In addition to the nature of judgment tasks, the contexts in which they are performed largely determine the strategies humans use for deciding. We are interested in the processes Soldiers initiate when making judgments and decisions in highly dynamic and ambiguous situations and in a short amount of time.

Broadly speaking, judgment strategies or processes can be intuitive, analytical/rational, or a blend of both. In situations characterized by the need to make a decision in a short amount of time, a deliberate, rational approach that includes thorough information search and processing is unrealistic given the nature of the situation. Instead, a more agile approach is one that takes human limitations in information processing into account and relies on mental shortcuts or heuristics, balanced with analysis when feasible. Different models of judgment and decision-making have been defined in terms of these intuitive and rational processes, and we discuss them at length in this report.

The idea that people are limited by their capacity to search for and process information, yet cognitively adaptive to the task environment, is a recurrent theme in this literature review. Moreover, this theme is central to how we conceive of MJP. In our view, based on a comprehensive literature review, Soldiers make effective decisions by appropriately framing the situation and recognizing relevant situational factors, which enables them to select a course of action that is most likely to result in their desired outcome. In novel, ambiguous, rapidly changing situations in which there is limited time, information, and resources, MJP is primarily intuitive, in that it relies on domain-specific heuristics and well-organized knowledge to arrive at judgments quickly. If time and circumstances permit, this initial intuitive approach can be endorsed, corrected, or overridden by a more deliberate, analytical approach.

In the following section we will examine further the distinction between rational and intuitive judgment. In doing so we will outline four key approaches to judgment and decision-making, each of which expands our understanding of how proficient judgments are made and the extent to which they rely on different processes.

Rational vs. Intuitive Judgment

The distinction between rational and intuitive processes falls within dual-processing accounts of human behavior, which abound in cognitive and social psychology theories (Evans, 2008). These theories all have in common the notion that there are two different modes of processing, for which the most neutral labels available in the literature are System 1 and System 2 processes (Kahneman & Frederick, 2002; Stanovich, 1999). Evans's review of dual-process models suggests that most authors agree on the basic distinction between processes that are unconscious, rapid, automatic, and high capacity (labeled System 1), and those that are

conscious, slow, and deliberate (labeled System 2). For our current purposes, we will use the labels “intuitive” when referring to System 1 and “rational” when referring to System 2.

Historically, models of judgment and decision-making have been defined in terms of intuitive and/or rational cognitive processes (Hastie & Dawes, 2001). Rational judgment is defined in terms of a logical conclusion drawn from the available information that is supported by a mathematical proof. These models reflect an unbounded view of rationality in that they do not account for factors such as time constraints and environmental factors that might influence the judgment process. Rational judgment is at the core of normative models of judgment and decision-making, such as von Neumann and Morgenstern’s (1947) *Expected Utility* (EU) model, which proposes that individuals assess the expected utility of each outcome by multiplying the probability that the outcome will occur by the outcome’s valance (i.e., attractiveness). This process results in a rational decision such that the outcome with the highest expected utility is chosen.

Intuitive judgment, on the other hand, accounts for the observation that individuals often make choices that run counter to what is expected based on a rational analysis of the information provided. Intuitive judgment is defined in terms of the heuristics (i.e., mental shortcuts) and cognitive biases, which allow individuals to draw conclusions without going through a rational evaluation process (Kahneman, Slovic, & Tversky, 1982). This does not suggest that individuals using intuitive judgment are irrational; rather these models reflect a bounded view of rationality in that they account for constraints in the mind (e.g., limited working memory capacity and information processing capacity) and constraints in the environment (e.g., time and information), both of which influence the judgment process. Intuitive judgment is at the core of descriptive models of decision-making such as Kahneman and Tversky’s (1979) *Prospect Theory*, which seeks to account for the discrepancies between normative rules and actual behavior.

More recent models have incorporated both the rational and intuitive aspects of judgment and decision-making. Some researchers have proposed dual process (or two continua) models that distinguish between intuitive and rational cognitive operations (see Evans, 2008). A good example of this approach is the *Attribute Substitution Model of Heuristic Judgment* (ASM) proposed by Kahneman and Frederick (2005) to describe judgment and decision-making under uncertainty. This model represents a merger between the intuitive and analytic approaches. It is analytic in that the correct decision can be determined using rules of probability, and it is intuitive in that it elaborates on the role of heuristics in the decision-making process. Other researchers have argued that rational and intuitive judgment represent opposite ends of a single continuum. This is exemplified by Hammond’s (1996) *quasi-rationality* conception of judgment that assumes most judgments and decisions fall along the mid-point of the continuum, and hence are driven by both rational and intuitive processes. All of these models emphasize the need to consider both rational and intuitive judgment to fully understand the judgment and decision-making processes.

In this literature review, we summarize four approaches to understanding decision-making that account for both analytical and intuitive processes. We begin by giving a brief overview of rational decision-making models, highlighting some key areas in which they fall short of adequately accounting for judgment proficiency in real world settings. Next, we discuss the *Heuristics and Biases* (HB) approach, focusing on one model in particular: Kahneman and

Frederick's (2005) ASM. The third approach we discuss is called the *Adaptive Toolbox* (AT), which builds on research by Gigerenzer and colleagues on "fast and frugal" heuristics (e.g., Gigerenzer, Todd, & the ABC Research Group, 1999). The AT model differs from ASM in two key ways. First, AT focuses on decisions made in situations where the correct answer is not clearly defined, while ASM uses probability theory to determine the best decision. Second, the goal of the AT is to understand how individuals make decisions in real life settings, while the goal of ASM is to understand how individuals make decisions on concrete tasks (e.g., deciding which option is risky). We argue that these differences are what make AT more relevant than ASM for the purposes of this research effort.

Many real world decision environments are characterized by high complexity, ambiguity, time pressure, and limited information. Understanding these demands is important for understanding both the possibilities and limitations of human judgment and decision-making. The study of naturalistic judgments and decisions provides a useful examination of such demands and their impact on judgment and decision-making. The fourth and final approach we will discuss is that of *Naturalistic Decision-Making* (NDM) (Lipshitz, Klein, Orasanu, & Salas, 2001), which is concerned with how individuals, particularly experts, make decisions in real world settings. Although NDM does not explicitly address the distinction between rational and intuitive processes, it does provide a useful and intuitively-oriented account of proficient decision makers in naturalistic task environments. Further, we describe the prototypical NDM model, *Recognition-Primed Decision (*RPD*) model*, which suggests a two phase sequence in which a typically quick assessment is followed by more deliberate evaluation, time permitting.

Finally, in a complex and uncertain world, it might be said that decision makers are aided by a variety of tools to help them make reasoned choices and offset various risks and stakes. For example, in military contexts officers utilize the Military Decision-Making Process (MDMP) to help them choose the best course of action from the most feasible courses of action for a given situation. While useful in some respects, these aids are not without limitations akin to those that constrain human information processing. Nowhere have these trade-offs been more apparent than in research on problem-solving. In the final section of this literature review we highlight this research because it helps explicate the nature of expertise and what differentiates experts from their novice counterparts. The NDM's focus on proficiency lends itself to a discussion of expertise from this broader perspective. Hence, our discussion of NDM will also include relevant research findings from the problem-solving literature.

The Rational Model of Decision-Making

The two meta-theories of coherence and correspondence have influenced the direction of research on judgment and decision-making from its beginnings in the 1940s and 1950s. *Coherence* meta-theory refers to theories and models that are concerned with the coherence or the rationality of a person's judgments and decisions. Studies of rationality seek to determine whether behavior is coherent and conforms to axioms of probability theory and decision theory. People's deviations from expected-utility theory (i.e., from a presumed standard of rationality) are also considered the interesting phenomenon from this perspective (Goldstein, 2004).

The notion of *unbounded rationality* – the idea that individuals apply appropriate rules of probability and statistics when making decisions in all situations and under time constraints – is central to coherence-oriented attempts to understand judgment and decision-making. Examples of such rules of probability and statistical reasoning that rational models assume individuals employ when making decisions are shown in Tables 1 and 2. Note that the rules of statistical reasoning deal with the extent to which a sample is representative of a population. One of the most influential models is the Expected Utility (EU) model by von Neumann and Morgenstern (1947). As previously mentioned, the EU model assumes that individuals use mental arithmetic to determine the value of the different outcomes. Like other rational models, situational factors (e.g., time and limitation constraints; framing of the problem) and individual differences (e.g., affect, need for cognition, cognitive ability) are not considered by the EU model.

Table 1

Key Laws of Statistical Reasoning Assumed in Rational Models of Decision-Making

Law of Statistical Reasoning	Definition
Law of large numbers	Accurate conclusions are more likely when drawing on a large rather than a sample of observations.
Sample representativeness	Accurate conclusions are more likely when the sample of observations and the population share similar key characteristics.
Regression to the mean	Accurate conclusions are more likely when the individual understands that (a) extreme observations are likely to be followed by less extreme observations, and (b) extreme observation of one event is likely to be associated with a less extreme observation of an event that is slightly different than the event initially observed.
Sample validity	Accurate conclusions are more likely when the sample of observations captured the characteristics most relevant to the decision.

Table 2

Key Rules of Probability Assumed in Rational Models of Decision-Making

Rule of Probability	Definition
Base rate	The number of times an event has occurred in the past (prior probability).
Multiplicative rules for independent events	The probability that two independent events will occur is equal to the product of their individual probabilities (joint probabilities).
Multiplicative rules for dependent events	The probability that two dependent events will occur is equal to the product of their individual probabilities (conditional probabilities).
Additive rules for independent events	The probability that at least one of a number of independent events will be observed.
Additive rules for dependent events	The probability that at least one of a number of dependent events will be observed.

Lipshitz et al., (2001) identify rational approaches such as the EU model as having four essential characteristics: (a) *choice* (i.e., decision-making is conceptualized as choosing among

concurrently available alternatives), (b) *input-output orientation* (i.e., models focus on predicting which alternative will, or should be, chosen given a decision maker's preferences), (c) *comprehensiveness* (i.e., decision-making is conceptualized as a deliberate and analytic process that requires a relatively thorough information search), and (d) *formalism* (i.e., the development of abstract and context-free models amenable to quantitative testing).

Pure rational models with these characteristics are not directly relevant to the current research, so detailed descriptions are not provided. A key shortcoming of rational models is the very notion of completely unbounded rationality. Rational models of judgment and decision-making focus on making explicit the choices, uncertainties, and outcomes of the decision problem (Collyer & Malecki, 1998). Yet, research shows that the informational requirements of these models are too demanding in comparison to the limitations associated with human cognitive capacities (Gigerenzer & Goldstein, 1999; Lipshitz, Klein, Orasanu, & Salas, 2001), as well as the constraints imposed by real world environments. Furthermore, the time it takes to collect all of the necessary information required by rational models makes them ill-suited for situations requiring immediate action (Collyer & Malecki, 1998). This includes dynamic situations faced by military leaders characterized by insufficient information, lack of time, and criticality of outcomes (e.g., life or death of subordinates). Therefore, where military judgment and decision-making are concerned, the classical ideal of appropriately applying the rules of probability and statistics is often both prohibitive and unrealistic.

In sum, for real world situations characterized by complexity, novelty, ambiguity of information (e.g., not knowing the accuracy of the information you have as well as the amount of information you are lacking), as well as time pressure, typical human information processing capacities simply cannot handle the rigors imposed by rational models of judgment and decision-making. Further, because humans lack the mental capacity to optimize and behave in accordance with normative models, the validity of such models as a suitable description of human judgment and decision-making is questionable. In the next section we examine an alternative approach, which proposes that the cognitive processes that structure judgment and decision-making do not coincide with normative principles, but instead rely on simplifying mental shortcuts, or heuristics. While these shortcuts can lead to cognitive biases, heuristics are adaptive to the constraints of limited information processing capacity and the demands of situational conditions. As such, the *Heuristics and Biases* (HB) program, as it is known, provides a better account of people's systematic deviations from rational choice.

Heuristics and Biases (HB) Program

The dominant program of judgment and decision-making research since the 1970s has been the HB approach initiated by Daniel Kahneman and Amos Tversky (Phillips, Klein, & Seik, 2004). It is also considered under the umbrella of the coherence meta-theory of judgment and decision-making, although its primary contribution to research has been to demonstrate the sharp departures of human judgment from normative principles (rather than adherence to them). In particular, Tversky and Kahneman (1974) proposed that decisions are often made using psychological shortcuts or heuristics. For example, the representativeness heuristic refers to a tendency to make probability judgments based on the similarity of an event to an underlying source; the greater the similarity, the higher the probability estimate. Table 3 provides several

more examples of heuristics and biases, and which rule(s) of statistical reasoning/probability they violate.

Table 3

Heuristics and Biases in Judgment and Decision-making

Heuristic/Bias	Description	Violated Rules of Statistical Reasoning/Probability
Anchoring and adjustment	Tendency to make insufficient adjustments from an extreme starting point (or anchor) when estimating the probability of an event occurring.	Regression to the mean.
Availability	Tendency to overestimate the probability of an event occurring because it is easily retrieved from memory.	Law of large numbers. Sample representativeness.
Concrete information	Tendency to give more weight to observable information than abstract information even if the abstract information is more reliable.	Law of large numbers. Sample representativeness.
Dilution	Tendency to underestimate the probability that an event will occur when irrelevant information is given along with relevant information.	Sample validity.
Gambler's fallacy	Tendency to overestimate the probability of the occurrence of an event not previously observed.	Multiplicative rules of probability.
Ignoring relative frequency	Tendency to make estimates based on observed frequencies rather than on relative frequencies, ignoring the statistical independence of random, discrete events.	Base rate.
Misperceptions about equiprobability	Tendency to define incorrectly the probability that two or more events will occur as equal when in fact they are not.	Additive rules of probability.
Order effect	Tendency to estimate the probability of an occurrence based on either the initial (primacy) or most recent (recency) observations.	Law of large numbers. Sample representativeness. Regression to the mean.
Overestimating conjunctive events	Tendency to overestimate the probability that two events will occur.	Multiplicative rules of probability.
Representativeness	Tendency to assign an event to a category because it resembles other events in the category.	Law of large numbers. Sample representativeness.

Although psychologically straightforward, heuristics often lead to biases because relevant information (e.g., base rates) is frequently not taken into account. However, once uncovered, these biases are useful in that they serve to illuminate the heuristic nature of the underlying system (Gilovich & Griffin, 2002; Kahneman & Tversky, 1972). The HB approach has been applied to domains as diverse as accounting, management, and marketing, and helps account for a host of suboptimal decisions (Shanteau, 1992).

Attribution Substitution Model of Heuristic Judgment (ASM)

Recently, Kahneman and Frederick (2002, 2005) have proposed a model that incorporates findings from earlier work by Kahneman and colleagues (e.g., Kahneman, 2003; Kahneman & Tversky, 1979) called the *Attribution Substitution Model of Heuristic Judgment (ASM)*. The model expands on the earlier work by (a) using the notion of attribute substitution to explain why heuristics work, (b) describing the role of heuristics in judgments in both certain and uncertain situations, and (c) introducing a process by which judgments based on heuristics are modified or dismissed as inaccurate.

In describing their model, Kahneman and Frederick (2005) adopt the labels *System 1* and *System 2* (see Stanovich & West, 2002) to distinguish between intuitive and reflective (i.e., rational) cognitive operations that influence the judgment process. The cognitive processes in System 1 are fast, automatic, effortless, associative, and difficult to control. In contrast, the cognitive processes in System 2 are slow, serial, effortful, deductive, and deliberate. The systems also differ in terms of the informational content on which they act; System 1 processes act on content that is arousing (e.g., affective, concrete, and specific), whereas System 2 processes act on content that is neutral (e.g., involving statistics).

While both System 1 and System 2 contribute to the final judgment, the process begins with the intuitive operations involved in System 1. This intuitive judgment is the result of automatic processes that involve well developed schemas and/or productions (Anderson, 1990) that chunk information and procedures, and/or heuristics that allow for quick judgments based on incomplete information. That is, people use heuristics as a substitution for attributes that are not observed in the environment. The ASM model assumes that the heuristics lead to violations of both the laws of statistical reasoning and the rules of probability, and hence reduce rather than enhance decision accuracy. However, once System 1 produces a response, System 2 is accessed in an effort to determine the quality of the intuitive judgment. This evaluation can lead to an endorsement, correction, or overriding of the intuitive judgment produced by System 1. Thus, the ASM model allows for accurate heuristic-based judgments.

Several other characteristics of System 1 and System 2 are worth noting. First, both systems can be active at the same time. Indeed, the automatic operations in System 1 compete with the controlled operations in System 2 to influence the overall response (or judgment). While System 1 and System 2 are independent in terms of cognitive processes and the content acted upon, the impression generated in System 1 serves as an anchor for the deliberate process that

occurs in System 2. Thus, individuals who engage in deliberate decision-making processes are unaware that their final judgment is influenced by the impression generated at the unconscious level.

Perhaps the most relevant aspect of the model offered by Kahneman and Frederick (2005) is that it identifies the processes in System 2 that are likely to result in an effective judgment. For example, judgment is improved when individuals deliberately generate courses of action that are viable alternatives to the one generated by the intuitive process before acting. As we will discuss in a subsequent section, research on problem-solving concurs with this conclusion, although the extent to which a solution can be deliberately and rationally generated in naturalistic settings is questionable.

Cognitive Continuum Theory (CCT)

Before concluding our discussion of the ASM model, we turn briefly to a second model that also merges intuitive and analytic approaches. Unlike the ASM, which developed from the perspective of judgment coherence (i.e., rationality), Hammond's (1996) Cognitive Continuum Theory (CCT) developed out of the second meta-theory of judgment and decision-making called "Correspondence." Correspondence meta-theory refers to theories that are concerned with the correspondence of judgment with empirical facts. In other words, it focuses on the empirical accuracy of a judgment rather than its coherence or rationality. The CCT is an extension of Social Judgment Theory, which is primarily concerned with understanding how experts form judgments based on cues provided by the environment. Accuracy of judgment from the CCT perspective depends on the extent to which an individual's mental model matches the environment in terms of cues, relations between cues and the target event, as well as the relative importance of cues (Hogarth, 1987). Social Judgment Theory itself developed from Brunswik's (1952) Lens Model, which describes the relationships between the objective environment (or task system), the information that is available on this environment, the subjective perception and integration of this information, and the judgments and decisions to which they lead (Lipshitz, 1993).

In a pioneering *Psychological Review* article, Hammond (1955) showed how Brunswik's work on perception was relevant to the task of making judgment inferences from incomplete and fallible cues in the environment. More recently, Hammond (1996) proposed CCT and contrasts intuitive and analytic thinking by rejecting the notion that judgments and decisions must be based entirely on intuition or analysis in their pure forms. Instead he suggests that the cognitive processes that guide judgment and decision-making can be located along a cognitive continuum that ranges between intuition and analysis. A process is more intuitive (or less analytical) to the extent that it is executed under low control and low conscious awareness, rapid rate of data processing, high confidence in answer and low confidence in the method that produced it. Hammond's position is that judgments and decisions often involve both intuitive and analytic cognitive elements, which become blended in different strategies. As such, many decisions are located somewhere near the quasi-rational center of the cognitive continuum (Goldstein, 2004).

Contrasting ASM and CCT

Compared to the ASM model, CCT pays more attention to the task environment, making its assertions about judgment more relevant to our conception of MJP. Specifically, CCT posits that certain task properties are likely to induce more intuitive processing, while other task

properties are likely to induce more analytic processing. Thus, not only can cognitive processes be arranged on a cognitive continuum (as more or less intuitive or analytical), but so too can tasks be arranged on a task continuum that represents the extent to which they induce more or less intuition or analysis (Lipshitz, 1993). Hammond, Hamm, Grassia, and Pearson (1987) conducted an experiment with expert highway engineers to test CCT hypotheses about the interactive effects of task characteristics and mode of cognition on the quality of performance. They found support for task conditions inducing modes of cognition with corresponding properties.

In sum, Hammond suggests that most real-world decisions are made in a quasi rational manner, blending intuition and analysis. His CCT model takes into account the limited information processing capacity that constrains human cognition, but also recognizes that humans are adaptive to the nature of the judgment task. Like the ASM model, it blends intuitive and rational accounts of thinking and further explicates the nature and role of intuition in dynamic decision processes. Unlike the ASM model, however, CCT underscores the importance of analyzing the nature of the decision task at hand.

In concluding this section on the HB program, we find that the ASM model does provide a useful starting point for understanding the processes that underlie MJP. It accounts for departures from normality and proposes heuristics as simplified methods for coping with humans' limited information processing capacity. While acknowledging that such limitations impact judgment strategy, this program of research has little to say about actual task environments and how parameters of naturalistic or field settings impose additional constraints on judgment and decision-making. Therefore, at least two important aspects of the ASM model make it less valuable as the theoretical basis for understanding MJP. First, rather than being applicable to decisions made in situations where the correct answer is not clearly defined, the HB approach and the ASM model in particular utilize probability theory to determine a single best decision. Second, the goal of the ASM model is to understand how individuals make decisions on concrete tasks (e.g., deciding which option is risky) rather than to understand how individuals make real-life decisions in applied settings.

The AT approach, discussed next, takes both these aspects into consideration and returns to the Brunswikian origins of Social Judgment Theory by emphasizing the adaptibility of an organism's behavior to not only human limitations, but also environmental constraints (Goldstein, 2004). The approach specifies domain-specific heuristics that are adaptive in a world where decision-making speed and the ability to make use of limited information are paramount. As such, this approach is more clearly aligned with the decision-making requirements of novel, ambiguous, rapidly changing situations and is more relevant to understanding judgment proficiency in the military.

Adaptive Toolbox (AT)

The AT model was offered by Gigerenzer et al., (1999) as a way to describe the cognitive strategies available to individuals when making decisions in everyday life. The model is built on Simon's (1956) Satisficing Model that assumes human judgment is best understood in terms of bounded rationality rather than the unbounded rationality offered by earlier models. According to

the satisficing model, rationality is bounded by limitations in human cognition, and by the environmental conditions in which humans operate. Because of these constraints, individuals use a satisficing heuristic to make decisions, a process that ends when a reasonable, but not necessarily perfect conclusion is drawn. As such, people are, at best, rational given the information they have and the limitations of the human cognitive system. They do not consider every available option, but instead choose the one that best fits the situation and satisfies the decision maker (Collyer & Malecki, 1998; Simon, 1957). This means that judgments and decisions, as well as problem-solving in general, are not optimized *per se*, but satisfied. In some cases, satisficing leads to fast decisions. However, it can also result in an extended process that involves comparing the value of multiple attributes before reaching a decision.

The AT approach suggests that judgment and decision-making are developed over time and are based on each individual's past experiences. It provides the blueprint for the use of heuristics for solving domain or context specific problems (Gigerenzer et al., 1999). The heuristics found in the AT are based on three premises: (a) psychological plausibility (how people actually make decisions), (b) domain specificity (specialized heuristics based on cognitive and emotional building blocks), and (c) ecological rationality (the adaptation of heuristics to the social and physical environment in which they are used) (Gigerenzer, 2001).

The third premise, ecological rationality, is adapted from Simon's (1956) original conception of bounded rationality. More than just stipulating that humans rely on heuristics due to limitations in time, information, and computational ability, Simon proposed that these heuristics must be understood in the context of the environmental structures to which they are adjusted. The HB program does not consider task environment, which is the ecological and contextual aspects of bounded rationality. In recent years, ecological rationality has provided a successful alternative interpretation of the idea of bounded rationality.

The domain specificity characteristic of the AT model is encapsulated in the notion of *fast and frugal* heuristics. These are domain-specific heuristics that are computationally simple (i.e., fast) and sparing in their information requirements (i.e., frugal). While the HB approach often views heuristics as inferior, limited, and relied upon to the detriment of the decision-maker, Gigerenzer and colleagues (e.g., Gigerenzer & Todd, 1999) see heuristics as advantageous and representing a means by which information in the environment can be used to arrive at reasonable decisions. Fast and frugal heuristics stem from constraints on information processing, a consequence of which is that they make use of a limited search. As such, not all available information is processed, and only a fraction of this information influences judgment (Gigerenzer & Goldstein, 1999). This makes fast and frugal heuristics adaptable in situations in which decisions must be made quickly and with limited information, provided accuracy does not suffer too greatly (Goldstein, 2004).

Fast and frugal heuristics are considered similar to the satisficing heuristic in that they are bounded by the environment. They differ from satisficing in two ways. First, fast and frugal heuristics almost always provide a quick decision. Second, fast and frugal heuristics are clearly tied to the structure of the environment (i.e., ecological rationality). As a result, the AT includes bins that contain heuristics that can be used in specific situations. According to the AT model, individuals may only need to employ a single heuristic when making simple decisions. However,

multiple heuristics might be necessary when making complex decisions. Specifically, individuals employ heuristics that guide the search for information, determine when to stop the information search, and produce a final decision.

Many decisions require individuals to select between two or more alternatives without the benefit of sufficient information. In these instances, individuals are motivated to search for information that will facilitate the decision-making process. In some cases, individuals will employ a heuristic that leads to a simple random search for information. In other cases, individuals might use a heuristic that leads to a search guided by a single attribute that was previously useful in evaluating attributes in similar situations. Regardless, the fast and frugal heuristics lead to a quick information search. Further, because the AT model assumes that individuals make decisions under time and environmental constraints, individuals need to employ a criterion for stopping the information gathering process in a reasonable timeframe. When limited information is available, the individual may adopt a take-the-first heuristic approach. When using this heuristic, the individual stops searching for alternatives once an example that includes an important or relevant attribute is identified.

In sum, regardless of whether the decision is simple or complex, individuals employ heuristics to make decisions. For many problems, an optimal solution is not feasible, especially the kind borne out of novel, ambiguous, rapidly changing situations, where the optimal solution is not readily apparent, and may never be. Psychological shortcuts are adaptive to both the limited information processing capacity humans bring to most judgment and decision-making tasks as well as the structure of the environment. Unlike the general heuristics offered by Kahneman and his colleagues (e.g., Kahneman & Tversky, 1982), fast and frugal heuristics are specific to the context and take advantage of environmental constraints. This degree of specificity, according to the AT model, allows for smart heuristics that yield effective decisions (Gigerenzer, 2001). Both the classical rationality and HB programs largely ignore the important role played by the environment in shaping human behavior. In contrast, Gigerenzer and colleagues (e.g., Gigerenzer & Todd, 1999) explicitly acknowledge the task environment as constraining the type of judgment and decision-making in which individuals engage.

For our current purposes, the task environment involves real world settings in which decision makers confront novelty, ambiguity, and complexity under conditions of limited time and resources, either cognitive, material, or otherwise. We have argued in this review that it is important to understand judgment proficiency within this specific context. The AT model is useful in highlighting that the rationality of heuristics is not logical, but ecological, and that it is relative to the environment. Evolved capacities in humans to accommodate a limited cognitive system make heuristics simple; the structure of the environment makes them smart (Gigerenzer, 2001). Naturalistic Decision-Making (NDM), discussed later in this review, is particularly interested in decision-making under certain conditions: those of limited time, knowledge, and other limited resources. As such, NDM is related to bounded rationality, generally (Todd & Gigerenzer, 2001), but with even clearer parallels to ecological rationality, specifically. Both NDM and AT focus on simple decision-making heuristics that are task specific (versus general purpose) and computationally fast and frugal (versus optimizing).

A key distinguishing characteristic of NDM is its focus on proficient, expert decision makers. These are individuals with "…relevant experience or knowledge in the decision-making

domain who rely on their experience directly" (Phillips et al., 2004, p. 334). Expert decision-making in real world contexts is central to NDM research and further illuminates the nature of MJP. Before proceeding with a discussion of the NDM literature, however, it is useful to further explore the nature of expertise. In doing so, we will review several key distinctions between experts and novices that have contributed greatly to research on judgment and decision-making. The role of expertise is particularly relevant to military settings because of the hierarchical nature of the military organization. In the military, both officers and enlisted Soldiers continuously train to build expertise in their particular branches and military occupational specialty (MOS) in order to make effective decisions that will impact themselves, their unit, and their overarching mission. As such, most Soldiers in positions of authority have built a minimum amount of expertise in their MOS before being put in situations requiring them to make decisions and take action.

Problem-Solving Expertise

A great deal of what we know about expertise has been identified by researchers studying problem-solving. During the 1980s, problem-solving research witnessed a shift in interest from a focus on lab-based puzzles to examining how people solve problems in natural knowledge domains. The so-called transformation problems (e.g., Tower of Hanoi) dominant in lab research are relatively simple and knowledge-independent. Their popularity can be attributed to the fact that they allowed researchers to easily trace participants' problem-solving steps and identify whether heuristics were used in the problem solution. Yet, these steps and heuristics only provide limited insight into the kind of problem-solving required in natural knowledge domains. As such, researchers shifted their focus to problems in more varied and applied areas, such as physics, writing, and chess playing.

Perhaps an inevitable extension of this research was an interest in comparing the performance of experts and novices in specific domains, and accounting for any observed differences. Insights about problem-solving from this research have been important to our emerging understanding of how people solve problems as well as make judgments and decisions. In this section we examine in more detail the important role of knowledge in the demonstration of expertise, as well as the core processes that underlie both novice and expert problem-solving. We also take problem type into consideration and explore expertise in the context of the specific kinds of situations on which the current project is focused.

Importance of Knowledge

A well-documented finding is that experts solve problems differently from novices. In research comparing how experts and novices engage in problem-solving, one of the most predictable differences between the two groups is the amount of domain-specific knowledge possessed by each (Ericsson & Hastie, 1994). A general conclusion from expert-novice comparison research is that when people are dealing with familiar material they rely to a greater extent on previously memorized schemata, which are abstract mental structures of organized knowledge. Chase and Simon (1973) showed that experts do not apply different or superior processes to solving problems, but their better performance can be attributed to the nature, amount, and organization of knowledge they possess about a particular domain. In other words,

experts are able to apply previously learned knowledge and rules that led to a solution in the past (Hunt, 1994).

Schemata exist in networks and represent each individual's unique understanding of the world. Experts differ from novices in having large, rich, well-organized schemata comprised of declarative or factual knowledge about a particular domain. Problem-solving and the encoding and retrieval of information from long-term memory appear to be schemata driven (Lipshitz, Levy, & Orchen, 2006). By applying these schemata, experts are able to develop sophisticated, albeit abstract, representations of problems based on structural similarities among problems (Sternberg, 2000). Indeed, much of expert problem-solving depends on the expert's ability to learn how to describe the external world so that descriptions can be related to the abstract representation in the expert's memory. As such, schema application often depends on abstract, sophisticated analyses of situations (Hunt, 1994).

Recall that the intuitive judgment and corresponding processes underlying Kahneman and Frederick's (2005) notion of System 1 involves well-developed schemata. Because of reliance on schemata, problem-solving for experts is not nearly as effortful as it is for novices, who lack organized knowledge about the domain in question. Experts can quickly organize new perceptions into existing schemata and act with much less effort. Schemata, therefore, provide an orderly way to shift attention from one aspect of a problem to another. When applied correctly, they transfer the information processing burden from working memory, where the human problem-solver is weak, to long-term memory, where the problem-solver is relatively strong (Hunt, 1994).

Limits on working memory determine how complicated the representation of the problem can be (Hunt, 1994). A key finding in comparing experts and novices is that the former are able to recall more information about a problem than novices when the stimuli presented are meaningful (Glaser & Chi, 1988; Anzai, 1991). However, this apparent advantage disappears when *randomly* arranged versions of the same stimuli are presented (Ericsson & Hastie, 1994). Findings of this nature have been replicated in domains as diverse as chess, bridge, music, electronics, and computer programming.

In sum, the expert's advantage rests on being able to quickly attain an integrated representation of the problem situation based on deep rather than superficial features (Anderson, 1993). Accessing relevant schemata makes the problem meaningful and shifts the processing burden from working memory to long term memory.

Core Processes

Problem representation, discussed above, is the first and possibly most crucial step in most accounts of the core processes that underlie thinking and problem-solving. When people solve problems, not only is knowledge – an organized set of facts and principles related to some domain (i.e., schemata) – important, but so too are the cognitive processes that contribute to the effective application of extant knowledge structures in solution generation. Interestingly, one finding from expert-novice research is that domain-specific knowledge does not differentiate consistently experts from novices when solving *novel* problems (Gentner & Block, 1983;

Mumford & Connelly, 1991). Therefore, in addition to knowledge, more general production processes are necessary in order to successfully solve problems.

Several researchers have proposed stepwise conceptions of problem-solving (Nickerson, 1994), which seek to identify and prescribe the sequence of steps (i.e., the process of thoughts and actions) people take to solve a problem. Like decision researchers, problem-solving researchers have often been concerned with developing prescriptions for improving decision/problem-solving processes in addition to describing basic mechanisms. Three popular prescriptive conceptions include those proposed by Polya (1957), Hayes (1981), and Bransford and Stein (1984). Most models are variations on the first proposed by Polya (1957) who suggested that four steps comprise problem-solving: (a) understanding the problem, (b) devising a plan, (c) carrying out the plan, and (d) looking back. Building on these basic steps, Hayes proposed a six-step model: (a) finding the problem, (b) representing the problem, (c) planning the solution, (d) carrying out the plan, (e) evaluating the solution, and (f) consolidating gains. Lastly, Bransford and Stein (1984) proposed five "IDEAL" stages of problem-solving: (a) Identify the problem, (b) Define and represent the problem, (c) Explore possible strategies, (d) Act on the strategies, and (e) Look back and evaluate the effects of your activities.

Few studies have actually tested the descriptive validity or prescriptive utility of these kinds of stepwise models of problem-solving (Lipshitz, Levy, & Orchen, 2006). Nevertheless, common across these and other similar models of the problem-solving process are certain fundamental steps (Lubart, 2001; Reiter-Palmon & Illies, 2004): (a) defining a problem-solving goal, (b) accessing relevant information, (c) building a solution from this information, and (d) evaluating and refining the proposed solution. Table 4 summarizes each of the aforementioned models and shows for which stages or steps the models are aligned similarly or not.

An important implication of laying out the process in steps is the notion that problem-solving is fundamentally linear in nature. There is evidence to suggest, however, that when engaged in solving real world problems, people do not mentally progress through an orderly and predictable sequence of steps. This mirrors the departure in judgment and decision-making research from normative models to those highlighting the role of heuristics and biases. As Nutt (1984) concluded, the linear process that stepwise or phase models describe "…seems rooted in rational arguments, not behaviour" (p. 446).

For example, early scholars of managerial problem-solving assumed that managers solve problems in a rational, linear fashion (Wagner, 1991). While a rational approach is potentially advantageous for reasons related to training, research findings do not suggest that leaders adhere to a strict and consistently applied sequence of processes in dealing with complex, ambiguous workplace problems. Instead, it seems the application of different problem-solving processes is much more recursive. Similarly, Mintzberg, Raisinghani, and Theoret (1976) found that rather than follow a step-by-step sequence from problem definition to problem solution, managers typically searched the problem space with only a vague notion about the problems with which they were dealing. Furthermore, managers reported having little idea about what the ultimate solution would be until they found it.

Table 4

Summary of Cognitive Processes Associated with Problem-Solving

<table>
<tr><th>Scholar(s)</th><th colspan="11">Cognitive Processes transform the initial state of a problem into a goal state</th></tr>
<tr><td>Reiter-Palmon & Illies (2004)</td><td colspan="2">Defining a problem-solving goal</td><td colspan="3">Accessing relevant information</td><td colspan="4">Building a solution from this information</td><td colspan="2">Evaluating and refining the proposed solution</td></tr>
<tr><td>Polya (1957)</td><td colspan="5">Understanding the problem</td><td colspan="3">Devising a plan</td><td>Carrying out the plan</td><td colspan="2">Looking back</td></tr>
<tr><td>Hayes (1981)</td><td colspan="3">Finding the problem</td><td colspan="2">Representing the problem</td><td colspan="3">Planning the solution</td><td>Carrying out the plan</td><td>Evaluating the solution</td><td>Consoli dating gains</td></tr>
<tr><td>Bransford and Stein (1984)</td><td>Identify the problem</td><td colspan="4">Define and represent the problem</td><td colspan="3">Explore possible strategies</td><td>Act on the strategies</td><td colspan="2">Look back and evaluate the effects of your activities</td></tr>
<tr><td>Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares (1991)</td><td>Problem construction</td><td colspan="3">Information encoding</td><td>Category search</td><td>Specification of best-fitting categories</td><td>Category combination & reorganization</td><td>Idea evaluation</td><td>Solution implementa tion</td><td colspan="2">Solution monitoring</td></tr>
<tr><td>Davidson, Deuser, & Sternberg (1994)</td><td>Identifying and defining the problem</td><td colspan="6">Mentally representing the problem
o Selective encoding
o Selective combination
o Selective comparison</td><td colspan="2">Planning how to proceed</td><td colspan="2">Solution evaluation</td></tr>
</table>

In a related study, Isenberg (1986) compared the verbal protocols of 12 general managers and three college students as they solved a short business case. Compared to students, Isenberg found that experienced managers began planning action sooner, asked for less additional information, made more inferences from the data, and were less reflective about what they were doing and why. Furthermore, the best predictor of rated effectiveness of proposed problem solutions was the degree to which the managers reasoned analogically from their personal experience. The key departures from the rational model involved managers engaging in action early in the problem-solving process, conducting cursory versus exhaustive analyses, and basing analyses on personal experience with analogous problems instead of using more formal principles of problem-solving. Accounts such as these, which portray naturalistic problem-solving, further underscore the relevance of approaches like the AT and its fast and frugal heuristic content for helping us understand MJP.

In the problem-solving literature, the application of heuristics clearly distinguishes experts from novices. Research shows, for example, that experts make more frequent use of heuristics such as making qualitative representations of the problem, considering analogous problems, and analyzing problems into manageable components. In comparison, novices are much less likely to do so (Nickerson, 1994). In large part this is because their representation of the problem is less well developed, along with their network of relevant schemata. Glaser (1996) notes that in solving problems novices tend to display individual acts and judgments, whereas experts are able to integrate the latter into overall strategies. Similarly, perceptual learning starts with a focus on isolated variables, but over time and with experience, this shifts to perception of complex patterns. Lastly, Glaser highlights the fact that experts demonstrate an increased self-reliance and ability to form new strategies as necessary.

Not only do experts make more judicious use of certain strategies, but evidence suggests they also rely heavily on heuristics that are relatively specific to a domain. An expert physicist, for example, is able to represent problems and apply problem-solving strategies in ways that a novice cannot. Such strategies are highly specific to the domain of physics problems and cannot easily be applied more broadly. In contrast, domain independent strategies (e.g., means-ends analysis) can be used effectively across most domains, but are not as powerful if applied to a specific physics problem. Indeed, there is an important trade-off between the range of applicability of a heuristic and its power: The more widely applicable a heuristic is (i.e., less domain dependent), the less powerful it will be in any particular situation (Nickerson, 1994).

In research examining the military decision-making processes of experts versus novices, military experts focused on aspects of the situation that resembled previous situations they faced, and used general heuristics to choose a satisfactory course of action (Morrison, Kelly, Moore, Hutchins, Cannon-Bowers, & Salas, 1998). However, more experienced officers are more likely to recognize that any given situation might not fit a previous situation, and are more likely to recognize the situation as being more ambiguous than less experienced officers (Cohen, Freeman, & Thompson, 1998). In tactical situations, military experts are more likely to focus on characteristics of a particular enemy for that specific situation, while novice decision makers may only focus on the range of the enemy's weapons (Cohen et al., 1998). In this manner, experts are able to better judge the situation and buy more time to make the decision (Cohen et al., 1998). Another key difference between experts and novices in the military is an expert's

consideration of the second and third order effects of their decisions and the larger implications of their course of action. Novices are more likely to focus on the immediate outcome of their decision, such as survival of their unit and the neutralization of the enemy (Cohen et al., 1998).

To summarize, in highly novel situations, the effective application of varied problem-solving processes, in addition to any relevant knowledge, is advantageous to experts. Rather than apply these processes in a linear manner, however, it seems that experts are more recursive. Moreover, experts rely on a repertoire of domain-specific heuristics and other problem-solving strategies.

Problem Type

For the purposes of the current project, we are focused on novel, ambiguous problem situations that allow for discretion on the part of the Soldier, and which arise out of complex as well as dynamic tactical, cultural, and legal/ethical situations and environments. In these real world settings, in which time is short and demands are many, Soldiers are required to generate solutions to complex, rapidly unfolding problems. Moreover, these problems are embedded within a host of restrictions imposed by constraints on time and resources, by system demands, and by conflicting goals. We turn now to exploring expertise specifically within the context of these problem settings.

An important distinction exists between well-defined problems that have a known goal, a known methodology, a way to reach an answer, and one correct answer (which may not be known to the problem-solver, but is known to others), and ill-defined problems (see Sternberg, 2000) that have multiple possible goals, multiple ways of being solved, and multiple possible and acceptable solutions (Reiter-Palmon & Illies, 2004). This latter type of problem is most representative of the kind of situation on which the current project is focused. When faced with ill-defined problems, military leaders must first define the problem or situation at hand. This involves problem representation, which as we have seen is the key cognitive process that provides the context for the application of the other processes. Research shows that problem construction occurs relatively automatically, with problems being framed in ways that fit with the problem-solver’s past experiences and schemata (Reiter-Palmon & Illies, 2004).

One attribute of ill-defined problems is that they are generally solved in the context of ambiguous information. Marshall-Mies, Fleishman, Martin, Zaccaro, Baughman, & McGee (2000) suggest that in complex and dynamic environments, leaders must solve problems under conditions of considerable uncertainty. It is seldom fully clear what information is either relevant or irrelevant. Similarly, it may be difficult to obtain accurate, timely information and identify the key diagnostic information. This makes information search and encoding another key cognitive process essential to successful problem-solving. Information can be gathered from both internal sources (e.g., schemata, experience) and external sources (e.g. others’ memories and experiences, the internet). In either case, the results of that search need to be connected, synthesized, and encoded so as to facilitate solution production (Reiter-Palmon & Illies, 2004).

When people encounter a problem, the schemata most related to that problem are activated, and concepts connected to those schemata are retrieved. Searching and encoding activities are principally guided by cues resulting from the problem representation process (Reiter-Palmon & Illies, 2004). These cues activate relevant schemata, facilitating the retrieval of concepts connected to them. But, the advantages of having many search cues will only be realized if there is sufficient knowledge for these additional cues to activate. Therefore, in addition to its role in problem representation, domain-specific knowledge is also important for guiding information-search and for structuring the encoding of new information, especially for ill-defined problems. Reiter-Palmon and Illies (2004) indicate that because the information most related to a problem is activated automatically and quickly, it will have the most influence over the structure that generates solutions. This is akin to the satisficing heuristic discussed previously, in which time pressures in naturalistic settings dictate that a situation or problem be resolved quickly and effectively, but not necessarily perfectly. This is unless a concerted effort is made to undertake additional search and encoding activities. Therefore, in response to problems about which information is ambiguous, it is helpful (time permitting) to expend further cognitive effort and expand search and encoding of information beyond that initially activated. This description has clear parallels to Kahneman and Frederick's (2005) description of how deliberate processes inherent in System 2 are accessed in an effort to determine the quality of the intuitive judgment produced by System 1. While effective under certain circumstances, many field settings may not permit a more deliberate evaluation of the problem and possible solutions.

Another attribute of ill-defined problems is that they tend to be novel. Rather than allowing for the application of extant schemata in a rote fashion, novel problems present unfamiliar parameters and require atypical and adaptive solutions. Reiter-Palmon and Illies (2004) suggest that generating novel solutions necessitates that individuals search, combine, and encode concepts from categories that do not on the surface appear to be related. This combination and reorganization of extant schemata generates the new understandings that lay the basis for novel solutions (Mumford & Connelly, 1991). The appropriate use of heuristic strategies is also key to novel solution generation. Further, problem-solvers must be able to evaluate ideas and identify one or a set that work the best for the current situation. This additionally requires identifying potential pitfalls and difficulties that may arise. While idea generation is about divergent production, idea evaluation is more about convergent thinking to figure out which solutions should ultimately be implemented. In doing so, problem-solvers need to be able to evaluate a chosen solution against competing goals and identify both short-term and long-term consequences of implementing a particular course of action. Reiter-Palmon and Illies (2004) note that identifying as many consequences and obstacles as possible means that the problem-solver can formulate a better implementation approach as well as develop contingency plans in case a solution is ineffective or cannot be implemented successfully.

In sum, the way a problem is represented influences cue detection, information search, and solution generation. Therefore, problem representation is especially important in handling ill-defined problems, which tend to be ambiguous, novel, and include parameters such as time pressure, few resources, and limited information. Expertise in handling ill-defined problems also involves searching and encoding activities that are guided by cues resulting from the problem representation process. The use of heuristics helps to explain why knowledge and information most related to a problem is activated automatically and quickly and has the most influence in

solution generation. Expert problem-solvers in poorly defined situations are able to evaluate ideas and identify the one or set that works best for the current situation. This requires also identifying potential pitfalls and difficulties that may arise.

Hunt (1994) suggests that a picture emerges of an effective problem-solver as being one who has memorized a large number of tricks of the trade, so to speak, rather than one who has developed a single, powerful strategy for reasoning. He argues that research findings point to "…local optimality acquired at the expense of global consistency" (p. 394). In other words, people learn what to do in local situations rather than learning abstract principles. Medin and Ross (1989) propose that reasoning is case-based, and results from the accumulation and organization of domain-specific examples rather than the generation of abstract principles. Training Soldiers on domain specific principles within situational vignettes, however, has been demonstrated to be effective in training military decision-making (Shadrick, Crabb, Lussier, & Burke, 2007). Nevertheless, interesting parallels can be drawn to Gigerenzer and colleagues' notion of the AT in which fast and frugal heuristics take advantage of environmental constraints. The NDM approach, discussed next, similarly focuses on the constraints inherent in field settings because they "…establish the key eliciting conditions for making decisions and shape decisions through their constraints and affordances" (Lipshitz et al., 2001, p. 334). Expertise from the NDM perspective is equally about the proficient decision maker as it is about the field settings in which they operate. In the next section we will examine both in greater depth.

Naturalistic Decision-Making

In everyday life, expertise and decision-making are relatively inseparable. With the exception of purely psychomotor areas, it is expected that identified experts make good judgments and decisions in their domain of expertise (Herbig & Glockner, 2009). It is informative to examine judgment and decision-making at different levels of expertise, which is typically signified by individuals who have achieved exceptional skill in a particular domain. Indeed, as was discussed above, a key distinction that separates experts from novices appears to be the breadth and depth of their domain-specific knowledge (Phillips, Klein, & Sieck, 2004). While a great deal of research studying expertise has been conducted in laboratory settings, approximating expert performance under controlled conditions is somewhat limited. The naturalistic approach to conducting research on expert judgment is exemplified by the NDM framework (see Klein, Orasanu, Calderwood, & Zsambok, 1993; Lipshitz, Klein, Orasanu, & Salas, 2001; Salas & Klein, 2001; and Zsambok & Klein, 1997 for a review).

The NDM is the study of expert judgment and decision-making and began in the 1990s as a line of research juxtaposed with traditional paradigms of judgment and decision-making research. The theoretical foundation of NDM researchers is in basic agreement with the HB research program, in that both perspectives concur that human decision-making is qualitatively different from normative theories, and that this is true of both experts and novices (Phillips, et al., 2004). Yet, NDM is related to ecological rationality because it focuses on simple decision-making heuristics that are task specific (versus general purpose) and computationally fast and frugal (versus optimizing).

The NDM research has primarily examined how experts make decisions in environments characterized by time pressure, ill-defined goals, ambiguity, and high value outcomes of decisions (Ross, Shafer, & Klein, 2006). As such, the subject of interest is real-world decision makers faced with meaningful decisions about which they have relevant knowledge or expertise. While the emphasis is particularly on individuals in crisis situations (e.g., fire fighters, pilots, military leaders), Phillips et al., (2004) suggest that findings about expert judgments and decision processes observed from these domains also generalize to those that are less crisis-like.

In their review of the NDM literature, Lipshitz and colleagues (2001) state that one of the defining characteristics of NDM research is that it places "…the human (and hence boundedly rational) proficient decision maker at its center of interest and as its basis for prescription" (p. 333). Beyond placing the expert decision maker as its focus, NDM theories attempt to describe the process through which these experts make a decision. Other defining characteristics of NDM theories, as described by Lipshitz et al., (2001), include: (a) the use of matching techniques by experts in the decision-making process (for a description of matching see Lipshitz, 1994), (b) the application of NDM to domain- and context-specific situations, and (c) the development of empirically-based descriptive models of expert decision-making.

Research on naturalistic decisions has uncovered several new views of decision-making (Lipshitz et al., 2001). First, expert decision makers are not superior to novices because their mental processing begins to align more closely with that of normative theories. Rather, expertise is believed to lead to a broader and more refined set of heuristic processes that promote outstanding performance in the specific domains out of which they developed (Phillips et al., 2004). Here we see parallels with the AT approach proposed by Gigerenzer and colleagues. Beyond the use of fast and frugal heuristics, situation assessment is also a crucial component of the process for NDM types of decisions. Situation assessment involves the sizing up and construction of a mental picture of a situation such that the decision maker identifies and defines the problem at hand (Lipshitz, 1993). This is much like the problem representation process discussed in conjunction with problem-solving. Following situation assessment, the next most important process is option generation. However, Klein's (1998) focal conclusion is that, contrary to the traditional definition of decision-making as choosing among alternatives, proficient decision makers rarely compare among alternatives. Instead, they assess the nature of the situation and, based on this assessment, select an action appropriate to it. This set of observations led Klein (1998) to propose what he calls the Recognition-Primed Decision (RPD) model.

Recognition-Primed Decision (RPD) Model

In novel, ambiguous, rapidly changing situations, there is not enough time to apply normative choice rules. Instead, experienced decision makers follow a *recognition-primed decision-making strategy*, which involves identifying a single course of action through pattern matching. The Recognition-Primed Decision (RPD) model is the prototypical NDM model (Lipshitz et al., 2001). It describes how experts rely on extensive knowledge to make judgments about situations and decide how to act (Phillips et al., 2004). It was developed based on extensive interviews with experts in varied domains, ranging from firefighters to military command and control.

It is important to note that domain specific knowledge and experience play a crucial role in the RPD model. RPD cannot be executed without such knowledge. As was mentioned in the discussion on problem-solving, experience and knowledge are essential to assigning meaning to information[1]. Phillips et al., (2004) describe three variations of the model. The first pertains to familiar situations that are judged to be routine. In such cases, decisions are thought to be intuitive and automatic. Proficient decision makers understand situations by recognizing them as prototypical situations they have experienced previously and stored in long-term memory. A recognition match occurs, without deliberation, and becomes the basis for a course of action or decision.

The second variation exists to explain decision-making in ambiguous or unfamiliar situations. In such cases, experts think about the situation at hand and often search for more information to augment their preliminary assessment. Sometimes, this step is conducted based on the need to reconcile an inconsistency or unexpected piece of information. In either case, in the second variation of the RPD model, proficient decision makers put forth effort to generate an accurate assessment of the situation. In doing so a clear course of action becomes apparent. Particularly for this variation, mental simulation can be used to play out a story about the precursors to the current situation. The story that is most plausible further helps the decision maker to understand what is going on and arrive at a reasonable course of action.

In the third and final variation of the RPD model, prior to engaging in action, decision makers take steps via mental simulation to evaluate the initial course of action selected by the recognition match. In other words, the effectiveness of the selected course of action is tested mentally. This process continues until a course of action is settled upon that passes the test of mental simulation.

The RPD model is functional in that it does not seek to describe how decisions should be made, but rather how they are actually made by experts in specific domains (Lipshitz, 1993). What the model proposes is that experts focus on critical cues and identify causal factors. Focusing on these elements lessens information overload and confusion, both of which can paralyze novice decision makers in stressful, rapidly changing situations. The identification of cues and causal factors helps to establish accurate expectations, which together with plausible goals, are key to selecting an appropriate course of action. Further, serial selection on the basis of typicality means that reasonable actions can be selected quickly. Lastly, mental simulation promotes critical thinking (Lipshitz, 1993). Like experts studied in the problem-solving literature, proficient decision makers make use of the satisficing heuristic. In naturalistic settings, time pressure often necessitates quick solutions. A perfect solution is rarely deemed necessary; instead, the solution simply has to be effective in the context of the situation at hand.

[1] Funder (1987) noted that good judgment is the ability to go beyond the information given and to rely on one's broader knowledge and past experience. Authorities on artificial intelligence (AI) agree that a key difficulty in getting computers to understand language or solve natural problems is that computers use only the information they have been explicitly given, rather than the broad array of real-world knowledge and experience upon which humans rely. While psychologists might seek to eliminate human cognitive biases from the judgment process, such biases are, according to Funder (1987), the very same things that researchers in AI are finding necessary—but extremely difficult—to incorporate into that process.

The NDM researchers go beyond the HB approach in terms of the role of heuristics. While both approaches agree that human judgment and decision-making is qualitatively different from normative theories, the RPD program goes further than HB by dealing with issues of representation and process (Phillips et al., 2004). Depending on how a problem situation is represented, a range of different heuristics can be brought to bear. In this sense, NDM is much more aligned with the basic premises of the AT model, and ecological rationality in particular. In much the same way as fast and frugal heuristics are conceived of taking advantage of structures in the environment, so too does NDM regard heuristics as inextricably related to the task or knowledge domain to which they are applied. In order to effectively apply a heuristic, the problem must first be defined in some fashion. This can be done quickly and automatically, or more slowly and thoughtfully. This perspective is similar in many respects to the problem-solving outlook on expertise, which highlights problem representation as crucial to solution generation. According to NDM, expert decision makers are not better than novices because their processing starts to look more like that of normative theories. Rather, expertise leads to a broader and more refined set of heuristic processes that promote high performance within the specific task domains to which they are adjusted (Phillips et al., 2004).

Klein suggests that decision makers manage to act proficiently under time pressure by relying on domain specific expertise, which enables them to identify the situation quickly and accurately and to act promptly by accessing an action queue that is arranged with the appropriate action on top (Lipshitz, 1993). Experts' success at this is influenced greatly by their ability to identify important cues and causal factors, out of which primed recognition can take place.

The judgment and decision-making of experts is conceived as relatively intuitive, although the RPD model allows the decision maker an opportunity to deliberate in unfamiliar circumstances in order to assess the situation accurately. This is similar to the ASM model in that both System 1 and System 2 contribute to the final judgment, which starts with a more intuitive process that is evaluated by a more rational process. Interestingly, Hammond (of Social Judgment Theory and Cognitive Continuum Theory) recognized that human intuition is particularly useful because it can allow for the recognition of rare but diagnostic cues that are hard to incorporate into purely analytic judgment and decision-making. This seems to be precisely what NDM and AT researchers wish to highlight about the use of situationally-adjusted heuristics. Klein, more in keeping with ASM model, suggests a two phase sequence in which a typically quick preliminary selection based on matching is followed by more deliberate evaluation (i.e., mental simulation).

In all three cases (i.e., ASM model, AT model, and NDM), with increasing time pressure, decision makers make more use of intuitive decision processes, which require less time and effort to act. As such, decision makers demonstrate adaptability to the decision task at hand and adopt strategies that do not tax limited information processing capacity. The approaches differ in how they conceive of the role of the environment in shaping the heuristics used and whether and to what degree more deliberate, analytical processes are accessed to refine the initial, more intuitive judgment. In the next section, we will bring together the various themes from this literature review in support of how we conceive of MJP, linking the themes from the literature with the four key components of MJP.

Military Judgment Proficiency: A Synopsis

We began this report by defining military judgment proficiency (MJP) as a complex skill that involves four major components: (a) accurately framing decision problems, (b) detecting and interpreting important situational factors/cues, (c) forecasting the consequences of different courses of action, and (d) choosing an effective course of action based on the preceding three factors. The research and theories from the judgment and decision-making and problem-solving literatures reviewed here suggest that each component – individually and in combination – is essential to demonstrating good judgment, especially under novel, ambiguous, and rapidly changing circumstances. In this section we will summarize the key links between the components of our definition on MJP and the extant literature.

Problem-Solving and Expert Schemas

At the outset of any problem situation, an important skill is being able to quickly attain an integrated representation and accurately frame the situation in one's mind. Problem representation is a key cognitive process, one of several highlighted by problem-solving researchers as contributing to the effective application of extant knowledge in decision generation. Proficient judgment requires some amount of domain-specific knowledge (Ericsson & Hastie, 1994). Knowledge exists in structures called schemas or schemata, which themselves exist in networks and represent an individual's understanding of the world. Experts have large, rich, well-organized schemata composed of declarative knowledge about a particular domain. Problem-solving, including the encoding and retrieval of information, is largely schemata driven (Lipshitz et al., 2006). It is important to note that experts do not apply different or better problem-solving processes. Rather, their superior performance can be attributed to the nature, amount, and organization of knowledge they possess about a particular domain (Chase & Simon, 1973). As Hunt (1994) states, experts have the advantage of being able to apply previously learned knowledge as well as rules that led to a solution in the past.

The Role of Heuristics

The reliance of experts on both knowledge and rules is a key theme in this literature review. The application of previously learned knowledge in conjunction with mental rules is a hallmark of expertise. Heuristics, or psychological shortcuts, are particularly well-adapted rules for helping cognitively constrained humans handle the challenges imposed by various situational constraints on time, resources, and information. Moreover, they represent a key mechanism that underlies each of the proposed components of MJP. Research in judgment and decision-making and problem-solving acknowledges the importance of heuristics as an essential human adaptation to the task environment. Models differ, however, in whether they regard such heuristics as advantageous or not. For example, the HB approach views heuristics independent of the environment and as leaving humans susceptible to cognitive biases, which results in suboptimal decisions. In contrast, the AT and NDM approaches take the view that heuristics are highly adapted to the environment out of which they developed, and are therefore of substantial benefit to the humans that apply them.

A Quasi-Rational Perspective

We take the view, in accordance with the latter approaches (i.e., AT and NDM), that in novel, ambiguous, and rapidly changing situations in which there is limited time, information, and resources, situational framing, assessment, and forecasting happen relatively intuitively – guided by an underlying set of domain-specific schemata and heuristic processes that promote high performance within the specific task domains from which they developed. We do not, however, conceive of MJP as an entirely intuitive process. We suggest that in many situations in which the timeframe does not call for immediate action, a somewhat more deliberate, analytical approach is likely to be taken.

In accordance with the ASM and RPD models, we argue the MJP is likely to involve some analysis that serves as a check on the initial, heuristically-driven judgment. This means it can be endorsed, corrected, or overridden, but only if time and circumstances permit. This quasi-rational perspective on MJP is consistent with current thinking about judgment and decision-making in naturalistic settings. The RPD model is particularly useful in shedding light on expert decision-making. For example, it highlights a two-phase sequence in which a typically quick preliminary assessment of the situation (e.g., comparing features of the situation to prototypical situations experienced previously and stored in long-term memory) is followed by more deliberate evaluation of a selected course of action (e.g., mental simulation). Moreover, the forecasting aspect of mental simulation in the RPD model is particularly intriguing as a means to evaluate a chosen course of action against competing goals to identify both short-term and long-term consequences of implementing a particular course of action.

In order to move from theory to measurement, we believe it is most fruitful to focus here on the measurement of situational framing, assessment, and forecasting, as well as selecting a course of action, components of MJP that are most amenable to measurement in a situational judgment test. In the past, situational judgment tests have been used successfully to measure problem-solving and decision-making skills (e.g., Beal, 2007; Waugh, 2004; Motowidlo, Dunnette, & Carter, 1990). While the distinction between intuitive and rational judgment is important, and a pervasive theme throughout this literature review, it is not a distinction that can easily be measured using a paper and pencil situational judgment test. Each of the other components, however, is highly amenable to measurement via a situational judgment test. The kind and extent of knowledge (in the form of schemata) and heuristics that underlie these components of MJP are conceived as cognitive mechanisms that can only be derived indirectly through people's reports of how they frame a situation, what factors/cues strike them as important, and what outcomes they forecast as desirable. In the next section we discuss measurement issues at greater length and elaborate on methods for measuring each aspect of MJP.

Situational Judgment Test (SJT) as an Assessment Tool

In organizational and educational settings, there has been growing interest in a family of measures commonly known as situational judgment tests (SJTs) (Motowidlo, Dunnette, & Carter, 1990). Whereas the label SJT is widely used in employment settings, similar instruments are used in other domains under the label "tacit knowledge tests" or "practical judgment tests"

(Sternberg, Wagner, Williams, & Horvath, 1995). Regardless of specific label, these instruments all have in common the presentation of a written or video-based scenario that is accompanied by a set of alternative courses of action, from which the individual is asked to make choices. A variety of different response options are possible (McDaniel & Nguyen, 2001). In some cases the task is to select the single best course of action, or the worst course of action. Response option formats in which the respondent is asked to judge the quality of different options are known as knowledge type formats. Another type of format is the behavioral tendency format, for which the respondent is asked to identify the action they would most or least likely perform.

There are a number of reasons why SJTs are growing in popularity. First, asking examinees to respond to realistic scenarios is appealing because it seeks information about judgment in context. This is in contrast to the de-contextualized nature of many standardized tests. Second, it is common to find smaller subgroup differences (e.g., race or gender differences) for measures with a smaller g-loading than with traditional cognitive ability tests (Clevenger, Pereira, Wiechmann, Schmitt, & Harvey, 2001). Thus, the addition of less cognitively loaded measures holds promise as a means of simultaneously increasing validity and reducing adverse impact. Third, large-scale studies have shown that SJTs have substantial criterion-related validities (McDaniel, Morgeson, Finnegan, Campion, & Braverman, 2001).

Measuring Specific Constructs Using SJTs

Several attempts have been made to measure specific constructs using SJTs. For instance, researchers have used these tests to measure constructs as diverse as teamwork knowledge and skills (Stevens & Campion, 1999), interpersonal skills and problem-solving skills (Motowidlo, Dunnette, & Carter, 1990), adaptive performance (Arad, Borman, & Pulakos, 1999), integrity (Becker, 2004), and personality (Motowidlo, Hooper, & Jackson, 2006). As previously mentioned, SJTs have been used successfully to measure problem-solving and decision-making skills (e.g., Beal, 2007; Waugh, 2004; Motowidlo, Dunnette, & Carter, 1990). In addition to using SJTs to measure specific constructs, these tests can be written to reflect an underlying model, such as a set of competencies, attributes derived from a job analysis, review of the literature, or a theory of effective performance. One goal of this effort is to use a SJT to measure the various aspects of judgment proficiency, as specified by theory and by the literature review provided. We will return to this point in detail below.

Unfortunately, most efforts to develop SJTs that measure specific constructs have resulted in tests that are multidimensional, have low internal consistency reliability estimates, or otherwise display poor psychometric characteristics (Weekley, Ployhart, & Holtz, 2004). Indeed, the typical SJT correlates with cognitive ability, experience, and personality (McDaniel & Nguyen, 2001). One difficulty in designing SJTs to measure specific constructs is that their format may impose constraints on the type of constructs measured. For instance, because SJTs by their very nature measure judgment, it is likely not possible to construct an SJT that does not correlate to some degree with cognitive ability. In their meta-analysis of the criterion-related validities of SJTs, McDaniel et al., (2001) found a mean observed correlation between SJTs and cognitive ability of .36.

Chan and Schmitt (2005) argue that the format of the SJT does indeed impose certain constraints on the constructs it can measure. They argue that irrespective of the construct a researcher intends to measure, the dominant constructs measured are different than the intended construct. Specifically, they propose that the dominant constructs assessed by SJTs – regardless of the intended construct to be measured – are adaptability constructs that are likely a function of individual difference traits and the result of acquisition through previous experiences, and a contextual-knowledge construct that may be gained through experience. In brief, Chan and Schmitt believe the dominant construct assessed by all SJTs is practical intelligence, contextual knowledge, or simply judgment (Chan & Schmitt, 2002, Sternberg et al., 2000). Practical intelligence refers to the ability or expertise to effectively respond and successfully adapt to a variety of practical problems or situational demands.

Measuring Judgment Proficiency Using an SJT

In the current project, we are developing an SJT-based measure of MJP. To our knowledge, such a measure does not already exist. In developing the current SJT we sought a somewhat innovative measurement approach. Unlike typical SJTs, which present a scenario and ask respondents to provide ratings about various courses of action one could take in the context of the scenario, we developed additional judgment question types, based on our review of the literature and subsequent definition of judgment proficiency, that ask respondents to provide ratings that demonstrate how they evaluate key judgment precursors.

Specifically, we believe the SJT format is particularly amenable to measuring respondents' ability to identify the most critical cues and situational features (e.g., situational awareness), as well as forecast the most important second- and third-order effects associated with a course of action. In this manner, we are not only taking into consideration proficiency in choosing an effective course of action, but we are also taking into consideration two major components of that judgment and decision-making process in naturalistic settings: (a) Identifying the most relevant aspects in the situation, and (b) tying the course of action to a desired goal or end-state. As was highlighted in the literature review, proficient decision makers (e.g. experts) are able to focus on critical cues and identify causal factors. Based on this rapid assessment, a course of action is selected that satisfies the requirement of the situation. In our SJT, by asking questions matching these three components, we are not only able to look at each component individually, but we are also able to combine all three to assess optimal solutions. Because SJTs are considered low fidelity simulations, it is necessary to show how the results relate to more realistic experiences such as field training exercises.

SJT Development and Measurement Issues

Based on the assumption that an SJT is an appropriate format to measure judgment proficiency, we will now consider several additional development and measurement issues related to the SJT format. These include: (a) generation of item content, (b) item stem complexity, (c) response option generation, (d) response instructions, (e) determining the effectiveness of the response options, and (f) scoring the SJT. Each of these considerations will be discussed below, paying particular attention to how each will be addressed for an SJT-based

measure of judgment proficiency. We will use an example item throughout this section to illustrate various aspects of the SJT under development.

Generating SJT Content

A preliminary issue is how to determine the content of SJT items. The critical incident method (Flanagan, 1954) is often used for identifying item content. Typically, this involves asking subject-matter experts (SMEs) to recall exceptionally good and exceptionally poor examples of performance. The SMEs are asked to name the antecedent, or what led to the incident, the behavior that was performed that was exceptionally good or poor, and the consequence(s) of the behavior. With this approach, the antecedent will often become the stem for the SJT item, and the behavior can become one of the response options.

A second approach is to write SJT items to conform specifically to some underlying set of competencies, attributes identified in a job analysis, or literature review detailing attributes relevant to job performance. This second approach aims to measure specific homogenous constructs. There are advantages to both methods. Critical incidents provide a rich source of information, but can be expensive and time-consuming. Construct-driven approaches help to ensure that a specific construct is being measured, thereby increasing the content validity of the measure.

For the SJT under development here, we relied primarily on an approach similar to that for generating critical incidents. Specifically, we conducted focus groups with SMEs, who provided rich descriptions of situations in which they had made decisions under novel, ambiguous, and rapidly changing circumstances. At the outset, we sought examples of situations that fall into each of the four categories determined at the start of the project: (a) leader tactical, (b) cultural, (c) legal/ethical, and (d) leader non-tactical situations. Using a semi-structured interview protocol, researchers gathered information about the background of the situation, important elements (e.g., quantity and kind of resources, amount of control, time pressure, and other constraints), and the outcome.

Interviews were conducted with nine separate groups of SMEs, following which the research team drafted a set of sample SJT situations. A subsequent set of SME focus groups provided feedback on these first situations as well as additional information, based on which another set of situations were drafted. A third group of SMEs gave detailed feedback on the complete set of situations. The research team implemented modifications to the situations, accordingly. An example situational stem from the tactical scenarios derived from these focus groups is presented below:

> "You are a Team Sergeant located in a small Forward Operating Base (FOB). You receive credible information that a suicide bomber will be making his way towards your FOB the following day. You know what particular road he will take and that his intention is to attack the FOB. You and some of your men come up with a plan to walk to a position 15 km from the FOB to set up an ambush. You plan to do this during the night so as not to be spotted and tip off to the would-be suicide bomber. Your men have trained the local host-nation (HN)

military and police force about how to conduct night patrols and security checks in your IED-rich area of operations. Your plan involves close coordination with the local police and security forces before you depart so as to avoid coming in contact with them while you are doing the overnight trek; in this manner avoiding potentially catastrophic friendly-on-friendly fire. You have been training these forces for about 6 months and you know that they will be conducting nightly patrols, and although they are professional, they will fire upon any force they encounter at night before asking questions. Just before leaving the base, your new team leader, a Captain with 1 week of experience in country, tells you that he does not agree with the coordination part of your plan. He is concerned that the local forces might be corrupt and tip-off the suicide bomber or give away your position. He insists that you do the hike without coordinating with HN forces."

The SJT provided above falls into the leader tactical category. It should be noted that in contrast to the other situation categories, the leader non-tactical situations were more challenging to define clearly and seemed to encompass any situation that was not already included in the leader tactical, cultural, or legal/ethical categories. As such, the nature of the situations gathered initially for the leader non-tactical category was much more heterogeneous. Further, these situations tended not to conform well to the principal criteria we established for deciding whether a situation could be used: that it was characterized as being novel, ambiguous, and rapidly changing. As such, the research team chose to eliminate the leader non-tactical category.

Complexity of Stems and Stem Fidelity

A second issue emerged regarding the complexity of the item stems and whether they should be relatively simple or very detailed. Some SJT researchers have theorized that detailed stems are more valid because they better represent a sample of performance taken directly from the performance domain (McDaniel et al., 2001). In keeping with this hypothesis, other researchers have argued that the high degree of correspondence between the predictor and criterion domains for such samples of performance is precisely what explains the high criterion-related validities of SJTs (Chan & Schmitt, 2002; Lievens, Buyse, & Sackett, 2005). Finally, highly-detailed and specific stems may also have greater face validity and more positive test-taker reactions.

The degree of detail in the situation can be critical because even small changes in the amount of detail have been shown to effect how the situation is interpreted (Brooks & Highhouse, 2006). Overall, higher detail appears to be preferable to less detail because it reduces the opportunity for situation construal. However, care must be taken to ensure that reading level remains appropriate throughout. Some studies (e.g., Sacco, Scheu, Ryan, & Schmitt, 2000; Sacco, Schmidt, & Rogg, 2000) have shown reading level to be related to subgroup differences. Thus, if sufficient care is not taken, detailed stems could increase the chances for misinterpretation.

The issue of level of detail in the stem is related to the issue of stem fidelity. Ideally, item stems should have high psychological fidelity in the sense that they require the same cognitive operations as tasks performed on the job. In the case of assessing judgment proficiency, a high

level of detail in item stems is appropriate for maintaining high psychological fidelity. This is due to the fact that the situations requiring judgment proficiency in dynamic, ambiguous situations require appreciation of how to weigh many situation-specific factors at once. Therefore, in the development of this SJT we relied heavily upon input from SMEs to tell us about the appropriate kind and amount of detail for each situation.

Generating Response Options

Another key measurement consideration in the development of SJTs is how to generate response options. Although response options can, in some cases, be generated by the SJT developer alone, it is often prudent to seek input from SMEs. This increases the likelihood of gathering more responses for each item stem. Furthermore, the issues of response complexity and fidelity apply equally to response options as to item stems, and SMEs can help ensure response options are straightforward to comprehend as well as realistic.

Once a set of situations was written and edited for the current SJT, we conducted a second round of focus groups with SMEs. The purpose of these focus groups was to generate response options for the three questions associated with each situational stem. Because we developed these questions based on a review of the literature and our subsequent definition of MJP, it was necessary to use a targeted protocol for soliciting information to populate response options.

During the focus groups, the research team presented SMEs with situations to which they provided the following written responses: (a) describe how they would handle the situation, including sufficient rationale for their approach, (b) describe 3-5 plausible courses of action that could be taken in response to the situation, including both effective and ineffective actions, (c) describe 1-2 possible outcomes or effects for each course of action, and (d) describe key factors taken into consideration in making the original decision, including factors a novice might weigh too heavily. Each of these questions was asked in order to provide information that could be used later to generate response options.

For the example situation presented above, three sets of response options were generated, one each for courses of action, situational factors taken into consideration, and plausible outcomes. They are shown here without reference to specific response instructions, which will be discussed next.

Courses of action:

A. *Continue with mission as recommended by your team leader, do not inform HN forces of specifics or of your objective.*
B. *Tell HN forces to cancel all of their patrols for the next 24 hours; tell them you will be conducting a solo mission and they are to stay put.*
C. *Tell HN forces that you will be conducting a joint operation, send their patrols in a different direction, clearing the way for your team.*
D. *Object to your Captain's orders. Report to the Battalion Commander your plans and ask him to override the Captain's changes to your plan.*

E. *Change the plan such that you inform HN forces of the imminent suicide attack and have them lay out the ambush instead of your forces.*
F. *Conduct a joint mission with HN personnel; confiscate their communication equipment before you brief them on mission specifics.*

Situational factors taken into consideration:

A. *Possibility of friendly on friendly fire without coordination.*
B. *Compromising the operational security of the mission.*
C. *Rapport with HN forces if they feel we don't trust them.*
D. *Captain's reasons for not trusting your plan as you presented it.*
E. *Following your Commander's advice.*
F. *Preventing an imminent attack on the FOB at all costs.*

Plausible outcomes:

A. *Suicide bomber is killed; HN forces feel that you do not trust them and refuse to work with you any further.*
B. *Your patrol encounters a HN patrol en route; HN patrols fires at you and friendly-on-friendly firefight ensues.*
C. *Operation is compromised when a HN Soldier warns the suicide bomber of the impending ambush.*
D. *Your Captain reprimands you for not following his orders; he states that one bomber is not worth the risk to the team.*

Each set of responses for each situational stem presents a representative, but not necessarily exhaustive, list of options related to courses of action, situational factors taken into consideration, and plausible outcomes. We sought to generate responses based on SME input that are as neutral as possible (i.e., equally attractive), while at the same time including options representing both effective and ineffective manifestations of MJP. Lastly, in selecting options for situational factors and plausible outcomes, we attempted to include options that seemed feasible given the courses of action initially presented. As such, other situational factors and outcomes *could* conceivably come into play as someone judges how to handle the situation. However, the constraints of the test format necessarily limit the number of options that can be presented.

Choosing Response Instructions

Having considered various SJT stem and response generation methods, as well as the level of complexity in SJT stems and responses, it is important to also consider the issue of response instructions. The key issue here is deciding whether to use a behavioral tendency format in which the respondent is asked to indicate what he *would do* in a situation, or use a knowledge format in which the examinee is asked to indicate what he *should do* in a situation. It is possible that the criterion-related validities of the SJT will vary depending on the format used. While Ployhart and Ehrhart (2003) found that SJTs with *would do* instructions had higher criterion-related validities, McDaniel et al., (2001) found higher criterion-related validities for *should do* instructions in their meta-analysis of SJT validities. Recent evidence indicates that the

behavioral tendency approach is more likely to capture typical performance and correlate more highly with measures of personality; whereas, knowledge SJTs, considered a maximal performance measure, correlated more highly with measures of cognitive ability (McDaniel, Hartman, Whetzel, & Grubb, 2007). Because we wish to capture both elements in this measure, we elected to include questions eliciting both knowledge and behavioral tendency.

First, we will ask participants to rate the effectiveness of each of the options representing the plausible courses of action on a 7-point scale from 1, *very ineffective*, to 7, *very effective*. This response instruction format generates the largest amount of information, and solicits responses based on participant knowledge. Two additional questions based on a behavioral tendency approach ask participants to rate which of all of the plausible courses of action they would be most and least likely to take. There is evidence to suggest that asking about what the individual is "most likely" versus "least likely" to do captures different aspects of the judgment construct (e.g., Cucina, Vasilopoulos, & Leaman, 2003; McElreath & Vasilopoulos, 2002; Vasilopoulos, Goldenberg, Cucina, Hayes, & McElreath, 2005). Therefore, we chose to capture both of these pieces of information in our measure by asking participants to answer the following questions:

> *Which of the above courses of action (COA) would you be <u>most</u> likely to take (circle only one option)?*
>
> *Which of the above COA would you be <u>least</u> likely to take (circle only one option)?*

This first multiple choice question about courses of action most closely resembles a traditional SJT item in terms of its response instruction format. SJT measures typically, however, ask for ratings from either a knowledge or a behavioral tendency approach. Yet several recent calls in the literature have asked SJT researchers to include *both* types of response format to better understand how response endorsements relate to important criteria (e.g., job performance, training performance) and other variables of interest (McDaniel, et al., 2007; Ployhart & Ehrhart, 2003). Using both response formats here (knowledge and behavioral tendency) will enable us to examine their predictive relationship with key criteria, including their contribution relative to other predictors such as intelligence and personality.

The second multiple-choice item will ask about critical cues and situational factors. Participants will be provided with a list of environmental cues/factors present in the situation and will be asked to rate each cue/factor for its importance. This will allow the research team to discern which factors were perceived by participants as most and least important in each situation. The response instructions for this question ask participants to rate the importance of each factor on a 7-point scale from 1, *highly unimportant*, to 7, *highly important*. It is presently unclear whether rating the importance of situational factors relies more on knowledge or behavioral tendency. Given, however, that the response options themselves describe aspects of the situation, it is likely that ratings of their importance rely to a greater extent on knowledge.

The last multiple-choice question will assess the capacity of the participant to forecast the consequences and outcomes of different courses of action by asking him to provide likelihood ratings. Participants will be asked to indicate, from a list of plausible outcomes related to the situation, what they believe will be the *probable* outcome of choosing the most and least likely

courses of action selected previously. Unlike the other two multiple choice questions, which ask for a rating to be given for each course of action and situational factor, we will ask participants to answer only the following questions:

Probable outcome of the COA you are <u>most</u> likely to take: _______ *(mark one A-F)*

Probable outcome of the COA you are <u>least</u> likely to take: _______ *(mark one A-F)*

Traditional and modified SJT format type questions will elicit responses for three of the four elements of MJP: courses of action, situational factors, and plausible outcomes. In order to capture information about problem framing, we will include an open-ended question prompting free responses from participants. This open-ended question will ask participants to explain in 1-2 sentences what they believe is the problem or issue to be resolved in the situational stem. Rather than providing participants with options from which to choose, we believe that it is more appropriate to elicit open responses about how participants frame the situational problem at hand. Further, using this format for one of the four questions per stem allows us to explore its feasibility for future versions of this measure, and whether it provides useful information relative to the SJT format questions.

One final issue is to decide on a procedure for determining the effectiveness of SJT responses. At least three different methods are available, including SME scoring, empirical keying, and reliance on theory (Weekley, Ployhart, & Holtz, 2006). Research has compared these three methods extensively. The general conclusion is that empirically-devised and rational keys are roughly equivalent in terms of validity. For the current SJT, our plan is to gather expert ratings for each of the SJT responses from a group of SMEs.

Through the questions and methods described, we believe we will capture critical information regarding individuals' capabilities to (a) accurately frame decision problems, (b) detect and interpret important situational factors/cues, (c) forecast the consequences of different courses of action, and (d) choose an effective course of action based on the preceding three factors. In doing this we hope to capture the critical elements of MJP.

Summary

Our goal in writing this report was twofold. First, we sought to define and describe a skill we refer to as "military judgment proficiency," which is judgment and decision-making in environments characterized by cultural, legal/ethical, and tactical complexity. We reviewed relevant literature in the areas of judgment, decision-making, and problem-solving, which laid the theoretical foundation for our definition of the MJP construct. Based on relevant pieces of the extant literature, we defined MJP as a complex skill that involves: (a) accurately framing decision problems, (b) detecting and interpreting important situational factors and cues, (c) forecasting the consequences of different courses of action, and (d) choosing an effective course of action based on the preceding three factors. We argued that in ambiguous, novel, rapidly changing situations in which there is limited time, information, and resources, Soldiers demonstrating MJP are more likely to select an effective course of action by appropriately identifying the nature of the situation, recognizing relevant situational factors, and forecasting the best overall outcome(s) from the selected course of action, given the situation. In combination, these four components of

MJP enable Soldiers to achieve the best possible end-state when making decisions in highly ambiguous, dynamic, and complex situations.

Throughout the literature review section of this report, we revisited the notion that while people are limited by their capacity to search for and process information, they are nevertheless cognitively adaptive to the task environment. This theme is central to how we conceive of MJP, and was discussed in relation to several models of judgment and decision-making, including rational models, the Heuristics and Biases (HB) program initiated by Kahneman and Tversky, Hammond's Cognitive Continuum Theory (CCT), the Adaptive Toolbox (AT) approach proposed by Gigerenzer and colleagues, and Klein and colleagues exploration of Naturalistic Decision-making (NDM).

In our view, based on a comprehensive literature review, Soldiers make effective decisions by appropriately framing the situation and recognizing relevant situational factors, which enables them to select a course of action that is most likely to result in their desired outcome. In novel, ambiguous, rapidly changing situations in which there is limited time, information, and resources, MJP is primarily intuitive, in that it relies on domain-specific, adaptive heuristics and well-organized knowledge to arrive at judgments quickly. If time and circumstances permit, this initial intuitive approach can be endorsed, corrected, or overridden by a more deliberate, analytical approach.

A second goal of this report was to describe the development of an assessment tool that will distinguish among Soldiers on the MJP construct. We described the situational judgment basis of this measure, which relies on both traditional and modified SJT format questions. We described how the measure uses multiple formats to tap each of the components of MJP. Moving beyond theory to operationalizing this construct is an essential step toward establishing its nomological network. Moreover, from an applied perspective, being able to assess MJP can aid in the selection of Soldiers for specialized units or teams, such as Provincial Reconstruction Teams or Special Operations units, and can serve as the basis for the development of training that targets MJP. Based on this methodology we developed an assessment tool with 19 situational items - 8 tactical, 6 cultural, and 5 legal/ethical. In the next phase of this work we will develop a scoring procedure and embark on validation research, evaluating the reliability, validity, and other psychometric properties of the instrument, and determine the potential usefulness of the measure in applied settings.

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